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SAMPLING SURVEY RELATED TO POSSIBLE EMISSION POLYCHLORINATED BIPHENYLS (PCBs) FROM THE INCINERATION OF DOMESTIC REFUSE

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REPORT ON THE REGION V, SURVEILLANCE AND ANALYSIS DIVISION SAMPLING SURVEY RELATED TO POSSIBLE EMISSION OF POLYCHLORINATED BIPHENYLS (PCBs) FROM THE INCINERATION OF DOMESTIC REFUSE

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16. Abstracts

During the three week period October 20-November 7, 1975, ambient and stack sampling for polychlorinated biphenyls (PCBs) were conducted at a domestic incinerator in an effort to quantify the levels of PCB emissions associated with the incineration of domestic refuse. The stack sampling was performed at an incinerator equipped with an electrostatic precipitator using a modified EPA Method 5 sampling train. Xylene was used as the solvent for any gaseous PCBs present in the effluent. Ambient sampling was conducted, upwind and downwind of the incinerator, using hexane as the solvent in duplicate sets of three impingers in series. It was concluded that the particulate emissions contain PCBs; however, the amount emitted does not result in a measurable increase in existing ambient levels of PCB; the presence of PCBs in the vapor state could not be established because of contamination in the xylene used as the solvent; and the use of hexane as the absorbing reagent is appropriate for ambient sampling. Recommendations are given.

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Emission
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PCBs
Polychlorinated biphenyls

PRICES SUBJECT TO CHANGE

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Gerald Regan - Chief, Air Surveillance Branch
Stephen Gorannon - Chief, Air Data Analysis Section
Lucien Torrez - Chief, Special Projects Section

ABSTRACT

During the three week period October 20 - November 7, 1975, ambient and stack sampling for polychlorinated biphenyls (PCBs) were conducted at a domestic incinerator in an effort to quantify the levels of PCB emissions associated with the incineration of domestic refuse. The stack sampling was performed at an incinerator equipped with an electrostatic precipitator using a modified EPA Method 5 sampling train. Xylene was used as the solvent for any gaseous PCBs present in the effluent. Ambient sampling was conducted, upwind and downwind of the incinerator, using hexane as the solvent in duplicate sets of three impingers in series. The stack sampling results, which reflect the particulate catch only, ranged from 6.05 to 84.3 ug/m^3 and averaged 32.9 ug/m^3. The ambient sampling results averaged 170 ng/m^3 at the upwind site and 140 ng/m^3 at the downwind site. It was concluded that the particulate emissions contain PCBs; however, the amount emitted does not result in a measurable increase in existing ambient levels of PCB; the presence of PCBs in the vapor state could not be established because of contamination in the xylene used as the solvent; and the use of hexane as the absorbing reagent is appropriate for ambient sampling. Recommendations include: (1) retesting of the incinerator for particulate and gaseous emissions, test for PCBs in the dust collected in the electrostatic precipitator and evaluate the waste for approximate content of materials that may contain PCBs; (2) test two other incinerators for PCBs emitted (one which uses a wet scrubber for particulate control, the other which has no control equipment); (3) avoid unnecessary handling of ambient sampling in the field by conducting all sample preparation in a laboratory atmosphere.

REPORT ON THE REGION V, SURVEILLANCE AND ANALYSIS DIVISION SAMPLING SURVEY RELATED TO EMISSION OF POLYCHLORINATED BIPHENYLS (PCB's) FROM THE INCINERATION OF DOMESTIC REFUSE

1. INTRODUCTION

As a result of increased interest in measuring ambient polychlorinated biphenyl (PCB) levels near potential sources, it was determined that the Air Surveillance Branch (ASB), Surveillance and Analysis Division, Region V, EPA would undertake a project to quantify PCB levels associated with the incineration of domestic refuse. The manufacture of paper products using recycled paper has been identified as a major source of PCB in industrial waste effluent. It was felt that the same or similar products burned as domestic refuse would constitute a source of PCB to the ambient air. The ambient air has been suggested as an additional transport mechanism of PCB to the oceans and lakes.[1] The project was conducted jointly by ASB and the Central Regional Laboratory (CRL). CRL was tasked with method development and analysis.

2. OBJECTIVE

The objective of the sampling survey was to quantify ambient levels of PCB and to relate the levels of PCB to the incineration of domestic refuse as a possible source through appropriate stack and ambient sampling techniques.

3. AIR QUALITY STANDARD

No air quality standard has been established for PCB. However, it was recently determined that the goal for air emissions should be zero.

4. BACKGROUND

a. PROCESS DESCRIPTION

Household refuse collected by the City of Chicago is burned at municipal incinerators, thereby reducing the bulk waste prior to disposal in landfills. Of the four municipal incinerators, three are of particular interest in a study of PCB emissions.

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[1] Nisbet, I.C.T., and A.F. Sarofim. Environmental Health Perspectives Exp. Issue 1, 21 (1972).

The Calumet incinerator uses wet scrubbing techniques for control of particulate emissions. The Northwest incinerator uses electrostatic precipitators for particulate control. At the Southwest incinerator (the oldest incinerator) no controls for particulate emissions are used in the process. All incinerators burn essentially the same mix of domestic waste, each one servicing a particular area of the City. In this study, the Northwest incinerator was selected for an analysis of PCB emissions because of the accessible location of the stack sampling ports and supporting sampling platform. At this incinerator, the household refuse is dumped into any one of four refuse burning furnaces. The furnaces are of the water-wall type with an inclined reciprocating grate stoker with both forced and induced draft. The processes and control equipment are depicted in Figures 1 and 2.

b. LOCATION OF SAMPLING PORTS

The sampling was conducted in a rectangular air duct between the electrostatic precipitator and the induced draft fan. Sampling ports (as shown in Figure 2) were those that had been used during previous tests on the unit.

c. REFUSE FEED RATES

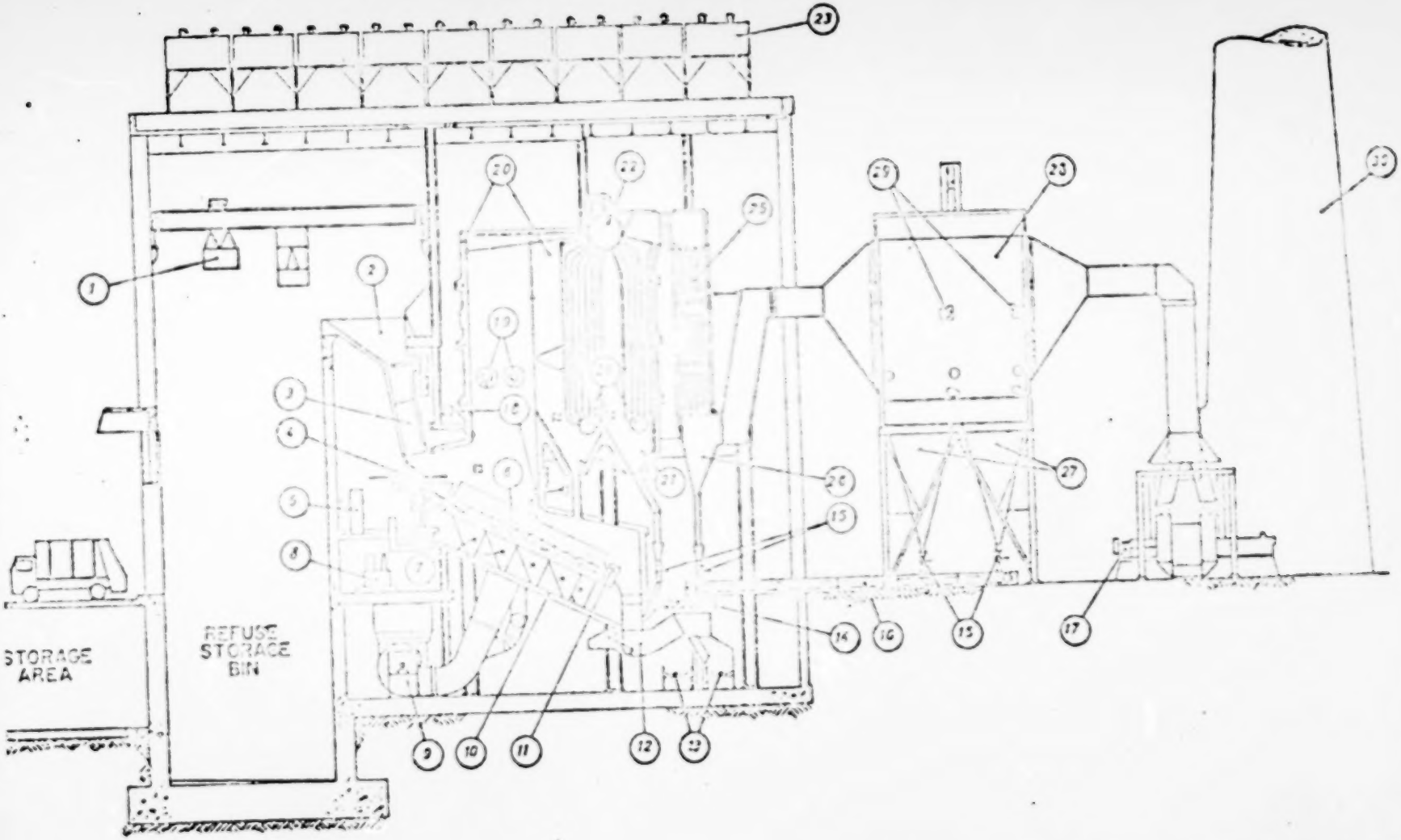
Approximate feed rates during the stack sampling runs were determined as follows. A count of the crane loads fed into the furnaces during each run was made and each crane load was assigned a value of 3100 pounds. The assigned pounds per load was taken from a test performed by the City of Chicago in March, 1975. The feed rates were estimated as follows: run No. 1-20 tons per hour, No. 2 - 17 tons per hour and No. 3 - 15 1/2 tons per hour. No attempt was made to determine the composition of the domestic refuse burned during the stack sampling tests.

d. SAMPLING EFFORT

(1) SOURCE SAMPLING

The sampling train used to sample for PCB was a modified EPA Method 5.[2] The front half of the train was the standard set-up with heated probe and filter. The back half was modified to split the sample and pass it through

[2]Herman, T.S., Development of Sampling Procedures for Polycyclic Organic Matter and Polychlorinated Biphenyls, EPA Contract No. 68-02-1255, August 1974.



CHICAGO NORTHWEST INCINERATOR

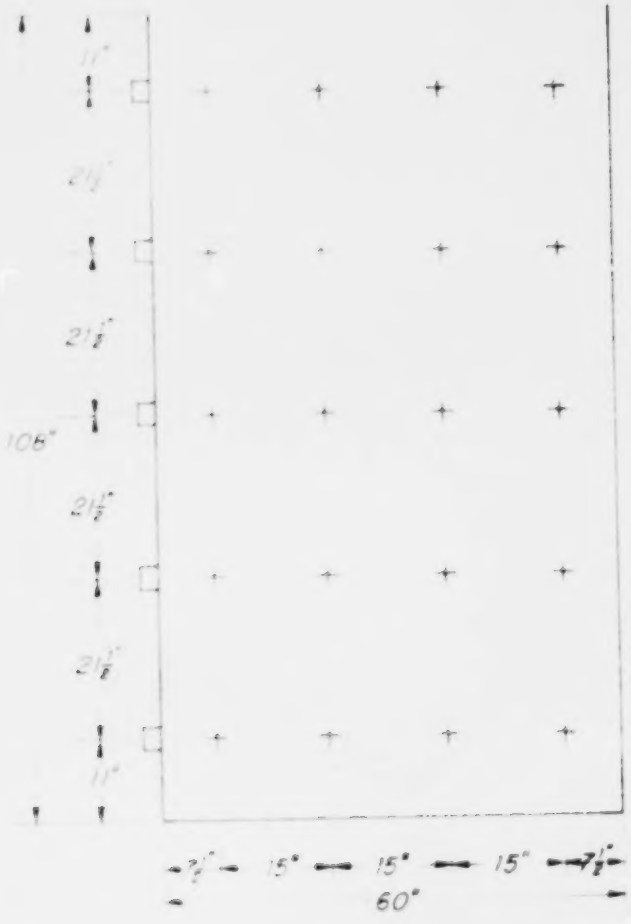
FIGURE 1: Incinerator Process

FIGURE 1-1

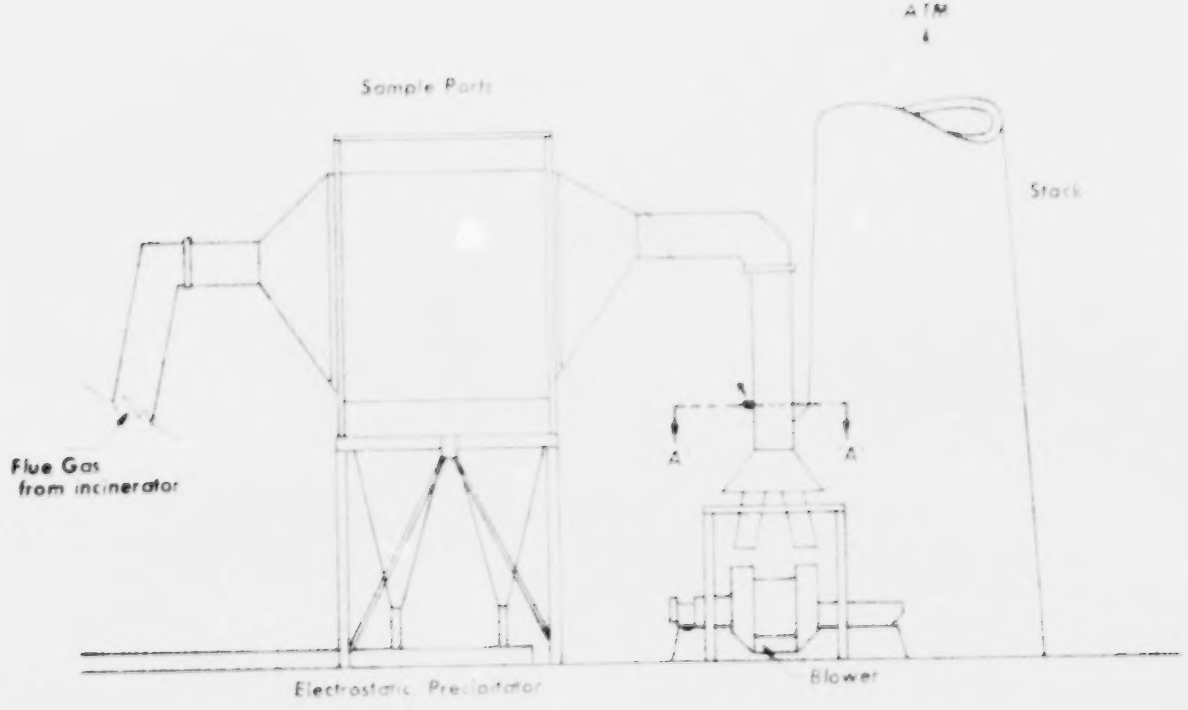
EQUIPMENT DESIGNATION

1. Refuse Cranes
2. Feed Hopper
3. Water Cooled Feed Chute
4. Hydraulic Feed Ram
5. Stoker Control Center
6. Martin Stoker
7. Undergrate Air Plenums
8. Hydraulic Power Unit
9. Forced Draft Fan
10. Automatic Siftings Removal Systems
11. Residue Discharge Clinker Roller
12. Martin Ash Discharger
13. Residue Apron Conveyors
14. Fly Ash Conditioning Screw
15. Automatic Rotary Valves for Fly Ash
16. Fly Ash Conveyor
17. Induced Draft Fan
18. Overfire Air Nozzles
19. Auxiliary Burners
20. Membrane Water-Walls
21. Boiler Hoppers
22. Steam Drum
23. Air Cooled Condensers
24. Mud Drums
25. Economizer
26. Economizer Hopper
27. Fly Ash Hoppers
28. Electrostatic Precipitator
29. Rapper Motor
30. Stack

FIGURE 2: Process Control Equipment



View A ENLARGED
SHOWING TRAVERSE POINTS

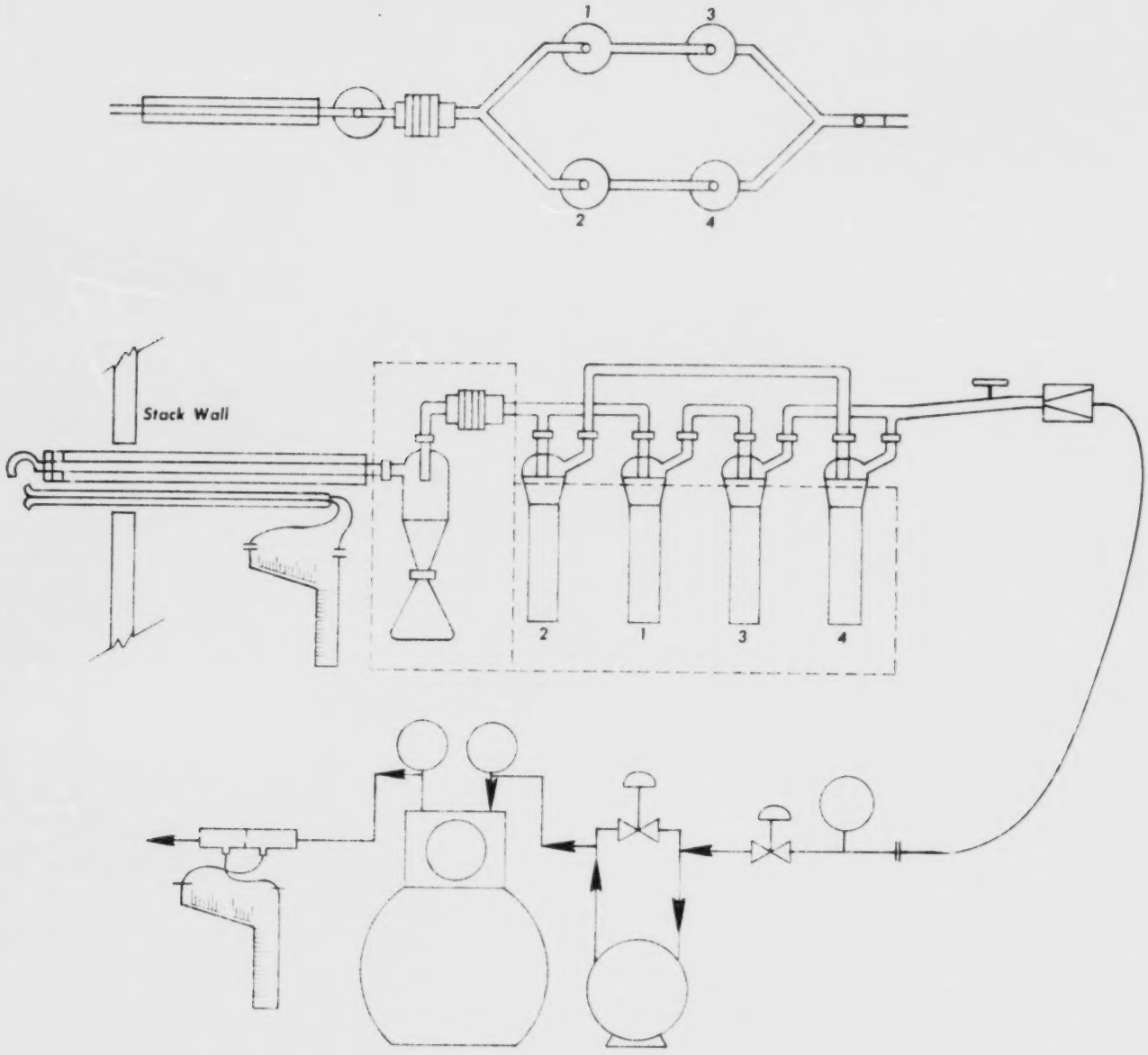


100 ml of xylene in each of the impingers in two pairs of modified Greensburg-Smith impingers (See Figure 3). Sampling procedures followed the techniques of EPA Method 5 with regard to sample rate, sample size, setting isokinetic conditions and sample time. The sampling deviated from Method 5 in regard to: twenty sample points were used in the traverse instead of forty as prescribed in Method 1 and the percent moisture in the stack gas was assumed to be constant at 10% for all three tests, a value consistent with moisture determinations from previous stack tests. The nozzle, probe, filter holder and glassware were rinsed with hexane prior to each test. One hundred ml of xylene were placed in each of the impingers to absorb any gaseous PCBs that might pass through the filter. At the end of each test the probe was removed and the ends sealed. The entire sampling train was taken to CRL for sample clean-up. For two of the three tests, the nozzle, probe and front half of the filter holder were rinsed with hexane. In the other test, the rinse was made with xylene. For all tests, the impingers and related glassware were rinsed with xylene. All samples were stored in glass containers sealed with teflon lined closures. The filter was removed from the filter holder and placed in a dessicator. The filters and samples were then turned over to CRL for analysis.

(2) AMBIENT SAMPLING

Two mobile vans (Mobil 2 and 3) equipped with generator power were used as sampling sites to perform ambient air sampling for PCBs during the three week period, October 20 - November 7. Mobile 2 was always positioned upwind of the domestic refuse incinerator. Mobile 3 was positioned downwind of the incinerator at or near the predicted point of maximum ground level concentration. It was determined that a minimum of 24 paired samples at each location would be required for data analysis. As a result, samples were collected in duplicate, twice per day using a sample train developed by CRL and described in Figure 4. Specific details on the steps performed in collecting the samples are described in Appendix A.

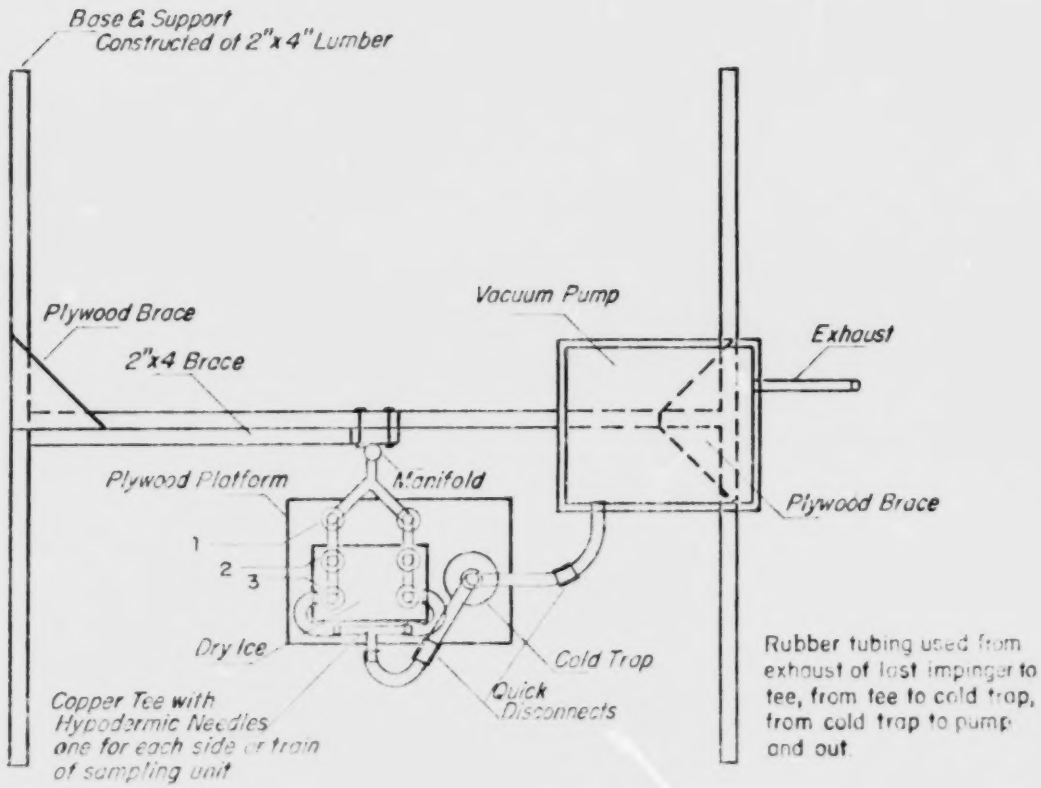
During the three weeks of ambient sampling, D.B. Turners' "Workbook of Atmospheric Dispersion Estimates" and current meteorological observations were used to estimate the



PCB SAMPLING TRAIN

FIGURE 3: Modified EPA Method 5 Sampling Train

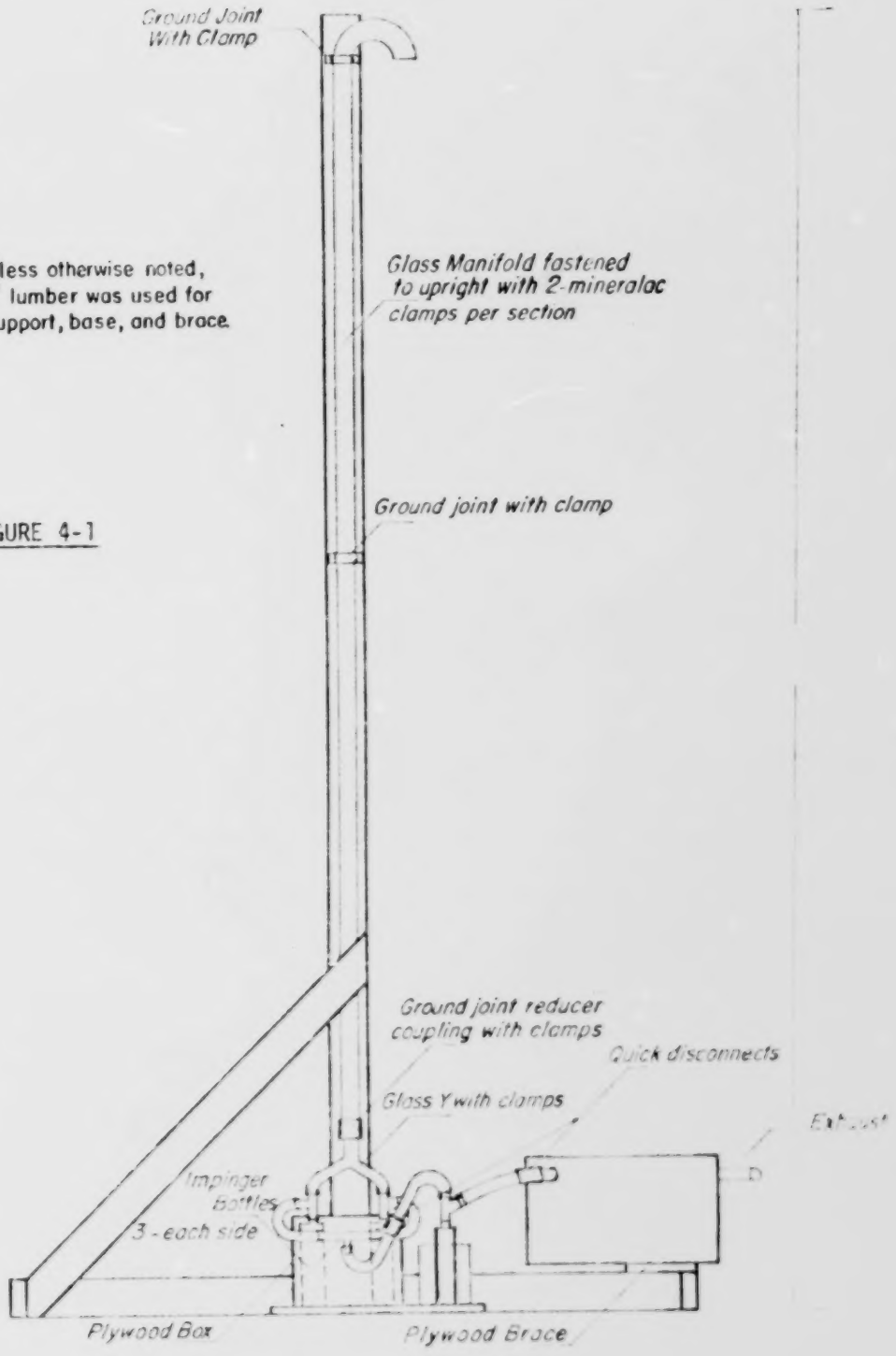
TOP VIEW OF PCB
SAMPLING EQUIPMENT



All ground joints - manifold, reducer, Y, impingers, etc. secured with appropriate clamps

FIGURE 4: Ambient Sampling Train

FRONT VIEW OF POB
SAMPLING EQUIPMENT



Unless otherwise noted,
2"x4" lumber was used for
the support, base, and brace.

FIGURE 4-1

Tee with Hypodermic Needle
for each side of sampling unit
3 - Impingers on each side
All ground glass joints with clamps

downwind sampling location at which the maximum ground level concentrations of PCB would be sampled. Stability determinations were made by ASB personnel based upon the sky cover and observed wind conditions as described in Table 3-1 of Turners' Workbook. The effective stack height (H) for the incinerator plume was calculated using Holland's equation (Reference Turner's Workbook). Once H and the stability condition have been estimated, the distance downwind of the maximum XU/Q (relative ground concentration) can be determined using the appropriate Figure: 3-5A through 3-5F of the Workbook.

As an aid in determining current wind information, a wind set was installed on the roof of the CRL building. The local forecasts made by the National Weather Service in Chicago were also incorporated into the selection of the sampling sites. Once in position, a second wind set was used at the downwind site to collect wind data during the sampling period.

As can be seen in Figure 4, the sampling train consists of a glass manifold, duplicate sets of three large bubblers in series, a liquid nitrogen trap and vacuum pump. Restricting orifices were used for flow control at a nominal 12 lpm. Sampling was conducted for 90 minutes to provide a sample volume of approximately one cubic meter of air.

Controlled laboratory experiments in which known amounts (512 ng) of PCBs (Arochlor 1248) were placed inside a section of the glass probe and then heated by applying electrical power to a nichrome wire wrapped around the probe showed that 90-100% of the PCBs are collected in the first bubbler, 0-10% in the second bubbler and less than 1 nanogram in the third bubbler. The experiments resulted in a satisfactory mass balance (115% recovery) and acceptable precision (97% and 126%) for the two sides of the sampling system. As detailed in Appendix A, a composite sample of the exposed hexane was made for each set of bubblers and returned to CRL for analysis.

e. LABORATORY ANALYSIS

(1) SOURCE SAMPLES

As described in paragraph 4d(1), the sample preparation included a hexane rinse of the nozzle probe and front half of the filter holder. In addition, following dessication of the filter, the PCB adsorbed on the

particulate was extracted with hexane. These samples were treated in the same manner as the ambient samples described below prior to analysis on a gas chromatograph. The xylene samples were injected directly into the gas chromatograph. These samples include the impingers used for PCB vapors in the effluent as well as one of the probe washes.

(2) AMBIENT SAMPLES

The exposed hexane solutions were dried with sodium sulfate and concentrated in a Kuderna-Danish evaporator to less than four ml. Each sample was divided into two ml fractions. One fraction was injected directly into a gas chromatograph equipped with an electron capture detector and a 50/50 injector splitter. The two columns are 6' x 1/4" glass and are packed with 4% SE-30/6% OV-210 and with 1.95% OV-17/1.5% OV-210 on 80-100 mesh gas chrom Q. The oven is maintained at 205°C and a 5% methane in Argon carrier gas was used. This fraction permits analysis of individual PCB mixtures; however, the detection limit proved to be too high for analysis and required perchlorination of the samples as follows. Approximately two milliters of chloroform were added to the second fraction and the resulting solution evaporated to less than 0.1 ml using low heat and an air or nitrogen stream. The process was repeated as necessary to remove all hexane. Antimony pentachloride (0.3 ml) was added and the solution heated to 180°C for 8 hours. The excess $SbCl_5$ was quenched with 3 ml of 6N HCl which was extracted 3X with 1 ml of 2N HCl, dried with sodium sulfate, concentrated to approximately 0.5 ml and injected into the gas chromatograph system described previously. The resulting decachlorobiphenyl peak was measured against a primary standard hexane solution and reported as total PCBs. Several of the higher PCB samples were analyzed for biphenyls which could act as an interferent in the perchlorination analysis. No biphenyls were detected in these samples.

5. DISCUSSION

a. SOURCE SAMPLING

The stack sampling for PCBs was performed in the exit breaching of the electrostatic precipitator on furnace No. 3. At the time the tests were conducted, units No. 3 and 4 were the only furnaces operating. The stack gas from units 3 and 4 is directed to the south smoke stack.

(1) SUMMARY OF RESULTS

The field data collected during each of the three stack sampling runs are described in Appendix B. As discussed earlier, because of equipment malfunction, the actual moisture present in the stack gas could not be determined and a constant value of 10% was assumed. A variation of ± 5% moisture would cause an error in the emission measurement of PCB of ± 2%. The results of the tests are summarized in Table 1. The emissions of PCBs from the incinerator when burning household refuse ranged from 8200 to 110,000 ug per minute based on the probe and/or filter catch. The total emissions based on the probe, filter and impingers could not be determined because of contamination in the xylene used as the absorbing reagent. This contamination resulted in a detectable limit for PCB present as a vapor of 500 ug.

(2) AVERAGE EMISSIONS

The average emission measured during the three stack sample runs was 41,060 ug/min. This equates to a concentration of approximately 32,880 ng/m^3 and is based on the particulate catch only. As stated earlier, the detectable limit of the solvent (xylene) was such that any PCBs present as a vapor in the effluent was masked. The amount of PCB detected as particulate is significant; however, the impact on the air quality in and around the incinerator is considered minimal. Once emitted, the concentration of PCB will be diluted 1000 times or more before reaching ground level resulting in an average ground concentration of 32.9 ng/m^3 or less. This subject is discussed in greater detail in paragraph 5, b, (2) below.

b. AMBIENT SAMPLING

The results of the ambient sampling are described in Appendix C. These data are as received from CRL and represent all analyses, uncorrected for blank values. Note that samples #13504 and 13517 are suspected of being contaminated and as a result are considered invalid. Overall, 25 sets of data are tabulated representing 25 duplicate sets of ambient samples, upwind and downwind of the incinerator, for a total of 100 individual samples.

(1) SAMPLE BLANKS

Laboratory reagent blanks (hexane) were analyzed to determine the detectable limit of the analytical method used for the ambient samples. Values of 7, 13, 6, 20, 0.0 and 0.0 ng/m^3 were obtained for an average of 8 ng/m^3. A detection limit of 30 ng/m^3 (two standard deviations above the mean) was used

TABLE 1

SUMMARY OF RESULTS

Run Number	1	2	3
Date	11/4/75	11/6/75	11/6/75
Stack Flowrate - SCFM dry	46,680	45,098	47,794
dscm	1,321	1,276	1,353
% Water vapor - % Vol (assumed)	10.0	10.0	10.0
% CO_2 - Vol % dry	6.0	8.0	8.0
% O_2 - Vol % dry	15.0	12.0	12.0
% excess air at sampling point	256.1	131.6	131.6
PCB Emissions			
Probe catch, ug	14.0	$<500^{+}$	1.8
Filter catch, ug	68.0	7.6	3.6
Impinger catch, ug	$<500^{+}$	$<500^{+}$	$<500^{+}$
ug/min.	1.1×10^{5}	1.1×10^{4}	8.2×10^{3}
ug/dscm	84.3^{x}	8.29^{xx}	6.05^{x}

$^{+}$Contamination of xylene resulted in detectable limit for PCB of 500 ug.

^{x}Based on probe and filter catch.

^{xx}Based on filter catch only.

to ensure correctness in the analyses for PCBs. As listed in Appendix C, sample blanks were also collected in the field beginning with sample #13568. The sample blanks were collected as a result of suspected contamination following the analysis of the first series of ambient samples. These proved to be unexpectedly high in the level of PCBs collected. Overall, 20 sample blanks were analyzed, the results of which are tabulated in Table 2. The blanks were obtained from the same supply of hexane as used for the ambient samples and were prepared in the interval between the twice per day ambient samples. Following the first sample, and subsequent rinse of the impingers, the appropriate amount of hexane was introduced into each impinger and poured directly into a sample container. Duplicate sample blanks, upwind and downwind were prepared and processed through CRL for analysis. The average of the sample blanks was 80 ng/m^3 which was used to correct the ambient data prior to statistical analysis.

(2) AMBIENT LEVELS OF PCB

As stated in the objective, it was intended to relate the emissions of PCBs resulting from the incineration of domestic refuse to the ambient levels downwind of the process. Appropriate modeling techniques were to be used as described in a protocol developed by ASB.[3] It was expected that the background levels of PCB (upwind of the incinerator) would be at or below the detectable limit of the analytical method and the maximum ground level concentrations off the incinerator (downwind) would be sufficiently high to allow for analytical detection. However, as tabulated in Appendix D, the ambient concentrations proved to be significantly higher than the detectable limit. This tabulation includes the PCB concentrations corrected for sample blank and related wind data. An examination of this Appendix reveals not only the high background levels of PCB found near the Northwest incinerator but also the apparent lack of any significant difference in the levels found upwind or downwind of the incinerator. This led to a revision in the statistical analysis of the data. It was determined to confirm the minimal impact of the incinerator emissions through modeling techniques and then to examine the paired sets of data for significant differences.

[3]Protocol for the Surveillance and Analysis Division Sampling Survey Related to the Possible Emission of Polychlorinated Biphenyls (PCBs) from the Incineration of Domestic Refuse, Undated.

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[3]Protocol for the Surveillance and Analysis Division Sampling Survey Related to the Possible Emission of Polychlorinated Biphenyls (PCBs) from the Incineration of Domestic Refuse, Undated.

TABLE 2

SAMPLE BLANKS, AMBIENT SAMPLING FOR PCB

Sample #	PCB ug/m^3	Station*	Date
13568	0.07	2A	11/3/75
13569	0.11	2B	"
13570	0.09	3A	"
13571	0.14	3B	"
13576	0.18	2A	11/4/75
13577	0.12	2B	"
13578	0.13	3A	"
13579	0.09	3B	"
13588	0.19	2A	11/5/75
13589	0.03	2B	"
13590	0.07	3A	"
13591	0.12	3B	"
13600	0.03	2A	11/6/75
13601	<0.01	2B	"
13602	0.02	3A	"
13603	0.01	3B	"
13620	0.02	2A	11/7/75
13621	0.02	2B	"
13622	0.03	3A	"
13623	0.07	3B	"

SAMPLE BLANK MEAN 0.08 ug/m^3
MAXIMUM 0.19 ug/m^3
STANDARD DEVIATION 0.057

*2A, 2B - Duplicate Samples, Upwind Station
3A, 3B - Duplicate Samples, Downwind Station

(a) GROUND LEVEL CONCENTRATIONS OFF THE INCINERATOR

The technique used in selecting the downwind sampling location and described in paragraph 4d(2) also provides a method for estimating the ground level concentration. In addition to an estimate of the distance downwind to the point of maximum ground level concentration, an estimate of the relative ground concentration XU/Q (M^{-2}) was also determined. Knowing Q, the emission rate and U, the windspeed, the ground level concentration X, can be calculated. Calculations were completed for the three stack sampling runs and are displayed in Table 3 below. The atmosphere stability is estimated from the windspeed and sky cover measured during the sample period. The windspeed is that measured at the downwind sampling site and listed in Appendix D.

TABLE 3

ESTIMATES OF GROUND LEVEL CONCENTRATIONS OF PCB IN THE INCINERATOR PLUME

Run No.	Stack Emissions(Q)*	Stability	Wind-Speed	Effective Stack Height	Distance	XU/Q	X
1	1.8×10^{-3}g/sec	D	1.4 mps	194 M	7.5KM	1.7×10^{-6}	2.2ng/m^3
2	1.8×10^{-4}g/sec	B	2.7 mps	110 M	0.76KM	1.2×10^{-5}	0.8ng/m^3
3	1.4×10^{-4}g/sec	B	2.7 mps	110 M	0.76KM	1.2×10^{-5}	0.6ng/m^3

*Based on particulate catch.

In all three instances, the predicted ground level concentration is below the detectable limit of the analytical method used in this study. This would tend to confirm the minimal impact of the PCB emissions from the incinerator and raises the question of the existence of other sources of PCBs in the area.

(b) DATA ANALYSIS

Several statistical tests were completed to determine significant differences in the data sets and are enclosed as Appendix E. Dixon's criteria for extreme observations were calculated.[4] The test results in-

[4] Experimental Statistics, National Bureau of Standard Handbook 91, Reprint, October, 1963.

dicated that the two upwind samples suspected of contamination should be rejected from any statistical analysis of the data set. Paired t-tests for significant differences in the 23 remaining duplicate sample sets, upwind and downwind, and the average upwind versus downwind sample sets are described. In each test, there was no significant difference in the data. Descriptive statistics are displayed in Tables 4 and 5. The average upwind sample was 170 ng/m^3 and the average downwind sample was 140 ng/m^3.

(3) WIND DATA AND RELATED PCB CONCENTRATIONS

Wind roses for the two wind sets used in the study are displayed in Appendix F. As stated earlier, the wind information as obtained from a set located on the roof of the CRL building was used in predicting the downwind sampling location. A second wind set was installed at this location to gather wind data during the ambient sampling period. As can be seen from the wind roses, there is similarity between the two sets of wind data. This is of particular interest in a city as complex as Chicago. The set located on the CRL building was unrestricted from obstructions to wind flow and measured the wind at a height of approximately 150 feet. The mobile wind set was generally located in what would be considered obstructed flow and measured the wind at a height of 11 feet. Pollution roses for the upwind and downwind sites and for the average of both sites are also described in Appendix F. In the format depicted, the pollution rose describes the direction associated with the highest average level of the duplicate PCB samples rather than the wind direction associated with the highest frequency of samples containing PCB. The averages of the duplicate samples are tabulated in Appendix E.

6. CONCLUSIONS AND RECOMMENDATIONS

a. CONCLUSIONS

(1) Particulate emissions passing through the electrostatic precipitator on the Chicago Northwest Incinerator contain PCBs; however, the amount emitted does not result in a measureable increase in existing ambient levels of PCB.

(2) The presence of PCBs in the vapor state in the stack gas could not be established because of the excessively high blank in the xylene used as the absorbing reagent.

TABLE 4

AVERAGE AMBIENT PCB CONCENTRATIONS (ug/m^3)
STUDY PERIOD 10/21/75 - 11/7/75

UPWIND SAMPLING SITE	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	OVERALL
Mean	0.17	0.26	0.12	0.19	0.14	0.17
Std. Dev	0.0	0.055	0.066	0.093	0.067	0.081
Maximum	0.17	0.31	0.19	0.36	0.24	0.36
DOWNWIND SAMPLING SITE						
Mean	0.18	0.16	0.10	0.11	0.18	0.14
Std. Dev	0.180	0.102	0.035	0.070	0.142	0.100
Maximum	0.31	0.28	0.14	0.20	0.38	0.38

TABLE 5

CUMULATIVE FREQUENCY DISTRIBUTION, BOTH SITES (ug/m^3)

CONCENTRATION	TALLY	PERCENT	CUMULATIVE
0.00 - <0.06	4	8.3	8.3
≥0.06 - <0.10	14	29.2	37.5
≥0.10 - ≤0.15	8	16.7	54.2
≥0.15 - ≤0.20	10	20.8	75.0
≥0.20 - ≤0.25	4	8.3	83.3
≥0.25 - ≤0.30	4	8.3	91.6
≥0.30 - ≤0.35	2	4.2	95.8
≥0.35	2	4.2	100.0
TOTAL	48	100.0	

(3) The use of hexane as the absorbing reagent is appropriate for ambient sampling of PCBs; however, considerable care must be exercised in sample handling to minimize contamination.

b. RECOMMENDATIONS

(1) In order to provide a more complete quantification of PCBs emitted to the atmosphere by incineration of domestic waste, it is recommended that additional tests be performed as follows:

(a) Retest the Chicago Northwest Incinerator for the following determinations:

1/ PCBs in stack emissions-particulate and gaseous.
2/ PCBs in the dust collected in the electrostatic precipitator.
3/ Evaluate waste for approximate content of materials that may contain PCBs.

(b) Test Chicago Calumet Incinerator for the following:

1/ PCBs in stack emissions-particulate and gaseous.
2/ PCBs in the scrubber waste water.

(c) Test Chicago Southwest Incinerator for PCBs in stack emissions-particulate and gaseous.

(2) Avoid unnecessary handling of ambient samples in the field. All sample preparation should be conducted in a laboratory atmosphere.

APPENDIX A

SYNOPSIS OF PCB MONITORING OPERATIONS

1. Two ASB vehicles, Travco (Mobile 3) and Ford (Mobile 2) vans equipped with generator power were used as mobile sampling sites to perform ambient air sampling for PCBs. One site (Mobile 2) was always upwind of the Chicago Northwest Incinerator; the other site (Mobile 3) was downwind of the incinerator stacks.

2. Mobile 2, always positioned upwind, did not have to change location during any particular day. Mobile 3, always downwind, did on several occasions relocate for the second sampling period of a particular day. The ASB meteorologist determined whether or not re-location was required for the second sampling period of that day. The determination was based on wind speed, wind direction, cloud cover, atmospheric stability and the daily forecast provided by the Chicago Office of the National Weather Service. Orientation of the mobile sampling stations into the wind was desirable but not always possible due to traffic patterns, one-way streets, restricted parking zones, lack of available parking areas, and interference by multi-story buildings - residential, commercial, and/or industrial.

3. Upon arrival of the mobile sampling stations at a designated sampling location, the following step-by-step operational procedure was performed:

   a. Clamp U-tube to top of manifold and fasten manifold support to base.

   b. Secure the diagonal brace (2x4) in position.

   c. Clamp the glass reducer coupling to the bottom of the manifold.

   d. Place the sampling train (duplicate set) in position and remove the interconnecting sections of glass U-tubes from #1 bubbler through #3 bubbler including the exhaust fitting from #3; do this to only one side at a time.

   e. Perform the following-one side of the train at a time-remove #1 bubbler and lift out the impinger; introduce 400 milliliters hexane into the bubbler and carefully insert the impinger back into the bubbler bottle and replace into the original position in the train (#1 is positioned in the ambient air outside of the plywood box); remove #2 bubbler, lift out the impinger and introduce 200 milliliters hexane, carefully insert the impinger and place this bubbler back into position in the train; remove #3 bubbler, lift out the impinger and introduce 300 milliliters hexane, replace impinger and put the bubbler back into the train; replace and clamp all U-tubes and the glass fitting leading to the copper tee critical orifice; repeat the above operations for the duplicate or second side of the sampling train.

f. Connect and clamp the Y-tube to both #1 bubblers and manifold.

g. Connect the two quick-disconnects in the rubber exhaust tubing between the copper tubing and cold trap and the cold trap and vacuum pump.

h. Completely fill (and pack) the plywood box with crushed dry ice - being sure that the four bubblers contained therein are totally surrounded by the dry ice; replenishment is usually necessary.

i. Fill the Dewar/Thermos flask (containing the cold trap) with liquid nitrogen and cover the mouth of the flask with aluminum foil; replenishment is usually necessary.

j. Check to insure that all connections - ball joints and quick disconnects are properly sealed.

k. Start the vacuum pump and note the time. Sample for 1 1/2 hours (90 minutes).

l. Read and note vacuum as indicated on the pump gauge; also read and note at the middle and end of the sampling period.

m. At the end of the sampling period pull apart the two quick disconnects and then shut off the pump.

n. Disconnect the Y-tube from the manifold and #1 bubblers.

o. Disconnect all U-tubes from one side of the sampling train.

p. Place sample receiving bottle and funnel in a convenient location; the sample bottle label should have the following information: date, time sampling period started, ASB site designation, assigned laboratory number, and type of analysis to be performed.

q. Rinse the funnel with a small amount of hexane, discarding the rinse solution and insert the funnel into the sample bottle.

r. Lift out #1 bubbler, remove impinger and carefully pour the remaining absorbing solution into the sample bottle, while this is being accomplished the impinger tube must be held above the funnel to avoid loss of sample; pour a rinse of 50-75 milliliters of fresh hexane into #1 bubbler bottle, insert the impinger into the bubbler bottle, shake carefully and place it back into the original position in the train; repeat the above sequences for removal of the exposed absorbing solutions from #2 and #3, pouring all into the same sample bottle; however, do not add fresh hexane to #2 and #3 bubblers.

s. Pour the rinse from #1 into #2, shake, and pour into #3, shake and pour into the same sample bottle - be sure to use the funnel; again the impinger from each bubbler being emptied must be held over the opening of the receiving vessel.

t. Remove the funnel from the sample bottle and cap the bottle, the bottle cap must have a Teflon insert.

u. Repeat the above sequence for the duplicate or second side of the sampling train placing the exposed sample into another appropriately labeled sample bottle.

4. If it is necessary to relocate for the second sampling period, the entire apparatus is dissassembled and re-assembled at the new location. If relocation was not required, the bubblers were immediately refilled with the specified amounts of fresh (unexposed) hexane and sampling commenced as soon as possible.

5. In addition to the above operational procedures performed by both mobile stations, Mobile 3 also utilized a portable wind set (which included sensors, mast, base and recording equipment) which was set up at each sampling location to obtain meteorological data specific to that location during the sampling period.

APPENDIX B

STACK SAMPLING FOR PCBs, NORTHWEST INCINERATOR, CHICAGO, ILL.

U.S. ENVIRONMENTAL PROTECTION AGENCY REGION V
AIR SURVEILLANCE BRANCH SPECIAL PROJECTS SECTION
STACK TEST REVIEW

COMPANY Chicago NW Incinerator

STACK IDENTIFICATION Breeching of Boiler 3

RUN NUMBER 1 DATE OF RUN November 4, 1975

1. Amount of water collected (milliliters) = 80.60
   Volume of water vapor collected (STP) = 3.82044

2. Dry gas meter volume at meter conditions (cubic feet) = 34.58
   Barometric pressure (inches of mercury) = 29.70
   Average orifice pressure drop (inches of water) = 0.760
   Average meter temperature = 70°F

3. Gas meter volume at STP (dry cubic feet) = 34.38

4. Percentage of moisture in gas stream = 10.00%

5. Percent composition of gas stream:

Oxygen.....	15.00%
Nitrogen.....	79.00%
Carbon Dioxide...	6.00%
Carbon Monoxide..	0.00%

6. Percentage of excess air = 256.14%

7. Dry molecular weight of gas stream (lb./lb-mole) = 29.56
   Wet molecular weight of gas stream (lb./lb-mole) = 28.40

8. Pitot tube coefficient (dimensionless) = 0.85
   Number of pitot tube readings = 20
   Average of square roots of velocity pressures = 0.4348
   Average gas stream temperature (°F) = 421°F
   Gas stream velocity (ft/sec) = 32.414
   Pitot tube readings:

.20	.12	.18	.18	.15	.24	.20
.26	.10	.10	.12	.14	.20	.24
.24	.24	.16	.22	.26	.26	

9. Stack dimensions, rectangular with sides (feet) = 5.00 X 9.00
   Stack area (square feet) = 45.00
   Volumetric flow at STP (cubic feet/min) = 46680

10. Nozzle diameter used for sampling (inches) = 0.305
    Sampling time (minutes) = 60.00
    Isokinetic rate (%) = 108.89

Date Dec. 8 1976

Signature R. Edwin Pfeltz

U.S. ENVIRONMENTAL PROTECTION AGENCY REGION V
AIR SURVEILLANCE BRANCH SPECIAL PROJECTS SECTION
STACK TEST REVIEW

COMPANY Chicago NW Incinerator

STACK IDENTIFICATION Breeching of Boiler 3

RUN NUMBER 2 DATE OF RUN November 6, 1973

1. Amount of water collected (milliliters) = 73.90
   Volume of water vapor collected (STP) = 3.50286

2. Dry gas meter volume at meter conditions (cubic feet) = 32.92
   Barometric pressure (inches of mercury) = 29.40
   Average orifice pressure drop (inches of water) = 0.920
   Average meter temperature = 70°F

3. Gas meter volume at STP (dry cubic feet) = 32.41

4. Percentage of moisture in gas stream = 10.00%

5. Percent composition of gas stream:

Oxygen.....	12.00%
Nitrogen.....	80.00%
Carbon Dioxide...	8.00%
Carbon Monoxide..	0.00%

6. Percentage of excess air = 131.57%

7. Dry molecular weight of gas stream (lb./lb-mole) = 29.76
   Wet molecular weight of gas stream (lb./lb-mole) = 28.61

8. Pitot tube coefficient (dimensionless) = 0.85
   Number of pitot tube readings = 20
   Average of square roots of velocity pressures = 0.4423
   Average gas stream temperature (°F) = 405°F
   Gas stream velocity (ft/sec) = 32.708
   Pitot tube readings:

.18	.20	.22	.23	.18	.24	.28
.26	.12	.10	.10	.10	.20	.21
.26	.26	.16	.20	.26	.24	

9. Stack dimensions, rectangular with sides (feet) = 5.00 x 9.00
   Stack area (square feet) = 45.00
   Volumetric flow at STP (cubic feet/min) = 47632

10. Nozzle diameter used for sampling (inches) = 0.305
    Sampling time (minutes) = 60.00
    Isokinetic rate (%) = 100.61

DATE Dec. 3, 1973

SIGNATURE D. Ebner Ryder

U.S. ENVIRONMENTAL PROTECTION AGENCY REGION V
AIR SURVEILLANCE BRANCH SPECIAL PROJECTS SECTION
STACK TEST REVIEW

COMPANY Chicago NW Incinerator

STACK IDENTIFICATION Breeching of Boiler 3

RUN NUMBER 3 DATE OF RUN November 6, 1975

1. Amount of water collected (milliliters) = 76.00
   Volume of water vapor collected (STP) = 3.60240

2. Dry gas meter volume at meter conditions (cubic feet) = 32.03
   Barometric pressure (inches of mercury) = 29.40
   Average orifice pressure drop (inches of water) = 0.990
   Average meter temperature = 70°F

3. Gas meter volume at STP (dry cubic feet) = 31.54

4. Percentage of moisture in gas stream = 10.00%

5. Percent composition of gas stream:

Oxygen.....	12.00%
Nitrogen.....	80.00%
Carbon Dioxide...	8.00%
Carbon Monoxide..	0.00%

6. Percentage of excess air = 131.57%

7. Dry molecular weight of gas stream (lb./lb-mole) = 29.76
   Wet molecular weight of gas stream (lb./lb-mole) = 28.55

8. Pitot tube coefficient (dimensionless) = 0.85
   Number of pitot tube readings = 20
   Average of square roots of velocity pressures = 0.4480
   Gas stream velocity (ft/sec) = 33.332
   Pitot tube readings:

.14	.20	.25	.27	.21	.24	.25
.25	.13	.10	.10	.11	.17	.25
.28	.26	.23	.20	.22	.24	

9. Stack dimensions, rectangular with sides (feet) = 5.00 x 9.00
   Stack area (square feet) = 45.00
   Volumetric flow at STP (cubic feet/min) = 47794

10. Nozzle diameter used for sampling (inches) = 0.305
    Sampling time (minutes) = 60.00
    Isokinetic rate (%) = 97.57

DATE 12-8-75

SIGNATURE [signature]

APPENDIX C

LABORATORY RESULTS, AMBIENT PCB SAMPLES
ug/m^3

SAMPLE #	PCB ug/m^3	AVERAGE ug/m^3	DIFFERENCE ug/m^3	STATION*	COMMENT
13500	0.28	0.35	0.13	2A	
13501	0.41	-	-	2B	
13502	0.39	0.36	0.07	3A	
13503	0.32	-	-	3B	
13504	1.16	-	-	2A	Contaminated
13505	0.29	-	-	2B	
13506	0.13	0.14	0.01	3A	
13507	0.14	-	-	3B	
13508	0.30	0.27	0.06	2A	
13509	0.24	-	-	2B	
13510	0.24	0.21	0.06	3A	
14511	0.18	-	-	3B	
13512	0.34	0.22	0.24	2A	
13513	0.10	-	-	2B	
13514	0.41	0.28	0.26	3A	
13515	0.15	-	-	3B	
13516	0.12	-	-	2A	
13517	1.67	-	-	2B	Contaminated
13518	0.12	0.14	0.03	3A	
13519	0.15	-	-	3B	
13520	0.16	0.17	0.02	2A	
13521	0.18	-	-	2B	
13522	0.16	0.16	0.01	3A	
13523	0.15	-	-	3B	
13524	0.17	0.30	0.25	2A	
13525	0.42	-	-	2B	
13526	0.43	0.46	0.07	3A	
13527	0.49	-	-	3B	
13528	0.37	0.39	0.04	2A	
13529	0.41	-	-	2B	
13530	-	-	-	3A	Sample Lost
13531	0.14	-	-	3B	
13532	0.30	0.26	0.08	2A	
13533	0.22	-	-	2B	
13534	0.23	0.21	0.04	3A	
13535	0.19	-	-	3B	
13536	0.14	0.12	0.04	2A	
13537	0.10	-	-	2B	
13538	0.18	0.17	0.03	3A	
13539	0.15	-	-	3B	
13540	0.11	0.19	0.15	2A	
13541	0.26	-	-	2B	
13542	0.15	0.14	0.03	3A	
13543	0.12	-	-	3B	
13544	0.25	0.24	0.02	2A	

*2A, 2B - DUPLICATE SAMPLES; UPWIND STATION
3A, 3B - DUPLICATE SAMPLES; DOWNWIND STATION

SAMPLE #	PCB ug/m^3	AVERAGE ug/m^3	DIFFERENCE ug/m^3	STATION	COMMENT
13545	0.23	-	-	2B	
13546	0.11	0.17	0.12	3A	
13547	0.23	-	-	3B	
13548	0.30	0.44	0.28	2A	
13549	0.58	-	-	2B	
13550	0.29	0.27	0.04	3A	
13551	0.25	-	-	3B	
13552	0.18	0.23	0.10	2A	
13553	0.28	-	-	2B	
13554	0.28	0.33	0.09	3A	
13555	0.37	-	-	3B	
13556	0.30	0.22	0.17	2A	
13557	0.13	-	-	2B	
13558	0.33	0.37	0.08	3A	
13559	0.41	-	-	3B	
13560	0.28	0.25	0.07	2A	
13561	0.21	-	-	2B	
13562	0.14	0.13	0.02	3A	
13563	0.12	-	-	3B	
13564	0.28	0.25	0.07	2A	
13565	0.21	-	-	2B	
13566	0.14	0.39	0.50	3A	
13567	0.64	-	-	3B	
13568	0.07	0.09	0.04	2A	Sample Blank
13569	0.11	-	-	2B	" "
13570	0.09	0.11	0.05	3A	" "
13571	0.14	-	-	3B	" "
13572	-	-	-	2A	Sample Lost
13573	0.28	-	-	2B	
13574	0.17	0.16	0.03	3A	
13575	0.14	-	-	3B	
13576	0.18	0.15	0.06	2A	Sample Blank
13577	0.12	-	-	2B	" "
13578	0.13	0.11	0.04	3A	" "
13579	0.09	-	-	3B	" "
13580	0.38	-	-	2A	
13581	-	-	-	2B	Sample Lost
13582	0.27	0.34	0.13	3A	
13583	0.40	-	-	3B	
13584	0.43	0.24	0.39	2A	
13585	0.04	-	-	2B	
13586	0.17	0.22	0.10	3A	
13587	0.27	-	-	3B	
13588	0.19	0.11	0.16	2A	Sample Blank
13589	0.03	-	-	2B	" "
13590	0.07	0.09	0.05	3A	" "
13591	0.12	-	-	3B	" "
13592	0.07	0.15	0.15	2A	
13593	0.22	-	-	2B	

SAMPLE #	PCB ug/m^3	AVERAGE ug/m^3	DIFFERENCE ug/m^3	STATION	COMMENT
13594	0.14	0.20	0.11	3A	
13595	0.25	-	-	3B	
13596	0.21	0.24	0.06	2A	
13597	0.26	-	-	2B	
13598	0.17	0.17	0.00	3A	
13599	0.17	-	-	3B	
13600	0.03	<0.02	<0.03	2A	Sample Blank
13601	<0.01	-	-	2B	" "
13602	0.02	0.02	0.01	3A	" "
13603	0.01	-	-	3B	" "
13604	0.34	0.23	0.22	2A	
13605	0.12	-	-	2B	
13606	0.09	0.11	0.03	3A	
13607	0.12	-	-	3B	
13616	0.19	0.16	0.06	2A	
13617	0.13	-	-	2B	
13618	0.10	0.10	0.01	3A	
13619	0.09	-	-	3B	
13620	0.02	0.02	0.0	2A	Sample Blank
13621	0.02	-	-	2B	" "
13622	0.03	0.05	0.04	3A	" "
13623	0.07	-	-	3B	" "
13624	0.14	0.16	0.04	2A	
13625	0.18	-	-	2B	
13626	0.13	0.12	0.02	3A	
13627	0.11	-	-	3B	

APPENDIX D

AMBIENT CONCENTRATIONS OF PCB CORRECTED FOR SAMPLE BLANK

DATE	SITE	START TIME	PCB CONC. ug/M3 *		PCB CONC. Avg. A&B	MOBILE WIND **		CRL WIND ***	
			A	B		DIRECTION	SPEED	DIRECTION	SPEED (mph)
10/21	Upwind	12:18	.20	.33	.27	Variable	8	260	7
10/21	Downwind	12:20	.31	.24	.28				
10/22	Upwind	11:45	1.08	.21	.65	210	9	200	15
10/22	Downwind	11:47	.05	.06	.06				
10/22	Upwind	13:45	.22	.16	.19	210	10	200	19
10/22	Downwind	13:40	.16	.10	.13				
10/23	Upwind	12:15	.26	.02	.14	180	6	190	15
10/23	Downwind	12:05	.33	.07	.20				
10/23	Upwind	14:10	.04	1.59	.82	180	6	180	15
10/23	Downwind	13:52	.04	.07	.06				
10/24	Upwind	11:15	.08	.10	.09	190	8	200	18
10/24	Downwind	11:45	.08	.07	.08				

*PCB Concentrations: Duplicate Samples
**Mobile Wind: Wind Speed and Direction measured at the Downwind Sample Site
***CRL Wind: Wind Speed and Direction measured on the roof of the CRL building

DATE	TIDE	START TIME	PCB CONC. ug/M^3*		PCB CONC. Avg. A&B	MOBILE WIND**		CRL WIND***	
			A	B		DIRECTION	SPEED	DIRECTION	SPEED (mph)
10/24	Upwind	13:00	.11	.36	.24	200	10	210	18
10/24	Downwind	14:15	.35	.41	.38				
10/28	Upwind	11:30	.29	.33	.31	290	6	290	12
10/28	Downwind	11:15	-	.06	.06				
10/28	Upwind	13:45	.22	.14	.18	020	6	360	16
10/28	Downwind	13:55	.15	.11	.13				
10/29	Upwind	11:15	.06	.02	.04	360	6	360	14
10/29	Downwind	11:25	.10	.07	.09				
10/29	Upwind	13:15	.03	.18	.11	010	6	010	12
10/29	Downwind	13:15	.07	.04	.06				
10/30	Upwind	11:15	.17	.15	.16	Equipment Down		110	11
10/30	Downwind	12:00	.03	.15	.09				

DATE	SITE	START TIME	PCB CONC. ug/M^3*		PCB CONC. Avg. ASB	MOBILE WIND**		CRL WIND***	
			A	B		DIRECTION	SPEED	DIRECTION	SPEED (mph)
10/30	Upwind	13:30	.22	.50	.36	Equipment Down		130	11
10/30	Downwind	13:45	.21	.17	.19				
10/31	Upwind	11:10	.10	.20	.15	160	11	210	21
10/31	Downwind	11:20	.20	.29	.25				
10/31	Upwind	13:00	.22	.15	.19	170	12	200	20
10/31	Downwind	13:05	.25	.33	.29				
11/3	Upwind	11:00	.20	.13	.17	210	5	220	11
11/3	Downwind	11:15	.06	.04	.05				
11/3	Upwind	13:00	.20	.13	.17	230	6	230	10
11/3	Downwind	13:10	.06	.56	.31				
11/4	Upwind	11:15	-	.22	.22	060	3	060	7
11/4	Downwind	11:45	.09	.06	.08				

DATE	SITE	START TIME	PCB CONC. ug/M^3*		PCB CONC. Avg. A&B	MOBILE WIND**		CRL WIND ***	
			A	B		DIRECTION	SPEED	DIRECTION	SPEED (mph)
11/4	Upwind	13:00	.30	-	.30	040	2	060	6
11/4	Downwind	13:45	.19	.32	.26				
11/5	Upwind	11:15	.35	.00	.18	180	6	210	5
11/5	Downwind	11:40	.09	.19	.14				
11/5	Upwind	13:00	.00	.14	.07	210	5	230	8
11/5	Downwind	13:40	.06	.17	.12				
11/6	Upwind	11:00	.13	.18	.16	180	6	210	12
11/6	Downwind	11:10	.09	.09	.09				
11/6	Upwind	12:45	.26	.04	.15	210	6	210	13
11/6	Downwind	13:10	.01	.04	.03				
11/7	Upwind	10:30	.11	.05	.08	170	7	210	15
11/7	Downwind	11:10	.02	.01	.02				

DATE	SITE	START TIME	PCB CONC. ug/M^3*		PCB CONC. Avg. A&B	MOBILE WIND**		CRL WIND ***	
			A	B		DIRECTION	SPEED	DIRECTION	SPEED (mph)
11/7	Upwind	12:15	.06	.10	.08	160	11	210	16
11/7	Downwind	13:00	.05	.03	.04				

APPENDIX E

DATA ANALYSIS, PAIRED t-TEST

Dixon Criterion for Extreme Observations

Upwind Site

$X_n = .82$
$X_{n-2} = .36$
$X_3 = .08$
$R_{i-a} = .406$

$r_{ij} = (X_n - X_{n-2})/(X_n - X_3)$
$(.82-.36)/(.82-.08)$
$.62$

$r_{ij} > R_{i-a}$ The highest value is rejected

$X_n = .65$
$X_{n-2} = .31$
$X_3 = .08$
$r_{i-a} = .413$

$r_{ij} = (X_n - X_{n-2})/(X_n - X_3)$
$(.65-.31)/(.65-.08)$
$(.34)/(.57) = .60$

$r_{ij} > R_{i-a}$ The second highest value is rejected

$X_n = .36$
$X_{n-2} = .30$
$X_3 = .08$
$r_{i-a} = .421$

$r_{ij} = (X_n - X_{n-2})/(X_n - X_3)$
$(.36-.30)/(.36-.08)$
$.06/.28$
$.21$

$r_{ij} < R_{i-a}$ The third highest value is retained

Downwind Site

$X_n = .38$
$X_{n-2} = .29$
$X_3 = .05$
$r_{i-a} = .406$

$r_{ij} = (X_n - X_{n-2})/(X_n - X_3)$
$(.38-.29)/(.38-.05)$
$.09/.33$
$.27$

$r_{ij} < R_{i-a}$ The highest value is retained

STATISTICAL ANALYSIS
Comparison Study

		Upwind			Downwind			AVG. of A,B		
Date	Time	A	B	Diff	A	B	Diff	Up-wind	Down-wind	Diff
10/21	PM	.20	.33	-.13	.31	.24	.07	.27	.28	-.01
10.22	AM	1.08	.21	.87	.05	.06	-.01	.65	.06	.59
10/22	PM	.22	.16	.06	.16	.10	.06	.19	.13	.06
10/23	AM	.26	.02	.24	.33	.07	.26	.14	.20	-.06
10/23	PM	.04	1.59	-1.55	.04	.07	-.03	.82	.06	.76
10/24	AM	.08	.10	.02	.08	.07	.01	.09	.08	.01
10/24	PM	.11	.36	-.25	.35	.41	-.06	.24	.38	-.14
10/28	AM	.29	.33	-.04	-	.06	-	.31	.06	.25
10/28	PM	.22	.14	.08	.15	.11	.04	.18	.13	.05
10/29	AM	.06	.02	.04	.10	.07	.03	.04	.09	-.05
10/29	PM	.03	.18	-.15	.07	.04	.03	.11	.06	.05
10/30	AM	.17	.15	.02	.03	.15	-.12	.16	.09	.07
10/30	PM	.22	.50	-.28	.21	.17	.04	.36	.19	.17
10/31	AM	.10	.20	-.10	.20	.29	-.09	.15	.25	-.10
10/31	PM	.22	.15	.07	.25	.33	-.08	.19	.29	-.10
11/3	AM	.20	.13	.07	.06	.04	.02	.17	.05	.12
11/3	PM	.20	.13	.07	.06	.56	-.50	.17	.31	-.14
11/4	AM	-	.22	-	.09	.06	.03	.22	.08	.14
11/4	PM	.30	-	-	.19	.32	-.13	.30	.26	-.04
11/5	AM	.35	.00	.35	.09	.19	-.10	.18	.14	.04
11/5	PM	.00	.14	-.14	.06	.17	-.11	.07	.12	-.05
11/6	AM	.13	.18	-.05	.09	.09	0	.16	.09	.07
11/6	PM	.26	.04	.22	.01	.04	-.03	.15	.03	.12
11/7	AM	.11	.05	.06	.02	.01	.01	.08	.06	.02
11/7	PM	.06	.10	-.04	.05	.03	.02	.08	.04	.04

Comparison Study

Paired t-Test $\alpha = .05$

Upwind

$N = 23$

$\bar{X}_d = .024$

$S_d = 406$

$t_{.95}(22) = 1.717$

$U = 1.717 \quad \left(\frac{.406}{\sqrt{23}}\right) = .145$

$\left|\bar{X}_d\right| < U$ Upwind A is not different from Upwind B

Downwind

$N = 24$

$\bar{X}_d = -.029$

$S_d = .130$

$t_{.95}(23) = 1.714$

$U = 1.714 \quad \left(\frac{.130}{\sqrt{24}}\right) = .045$

$\left|\bar{X}_d\right| < U$ Downwind A is not different from downwind B

Comparison Study

Paired t-Test α = .05

Upwind to Downwind

N = 23

$\bar{X}_d$ = .02

S_d = .100

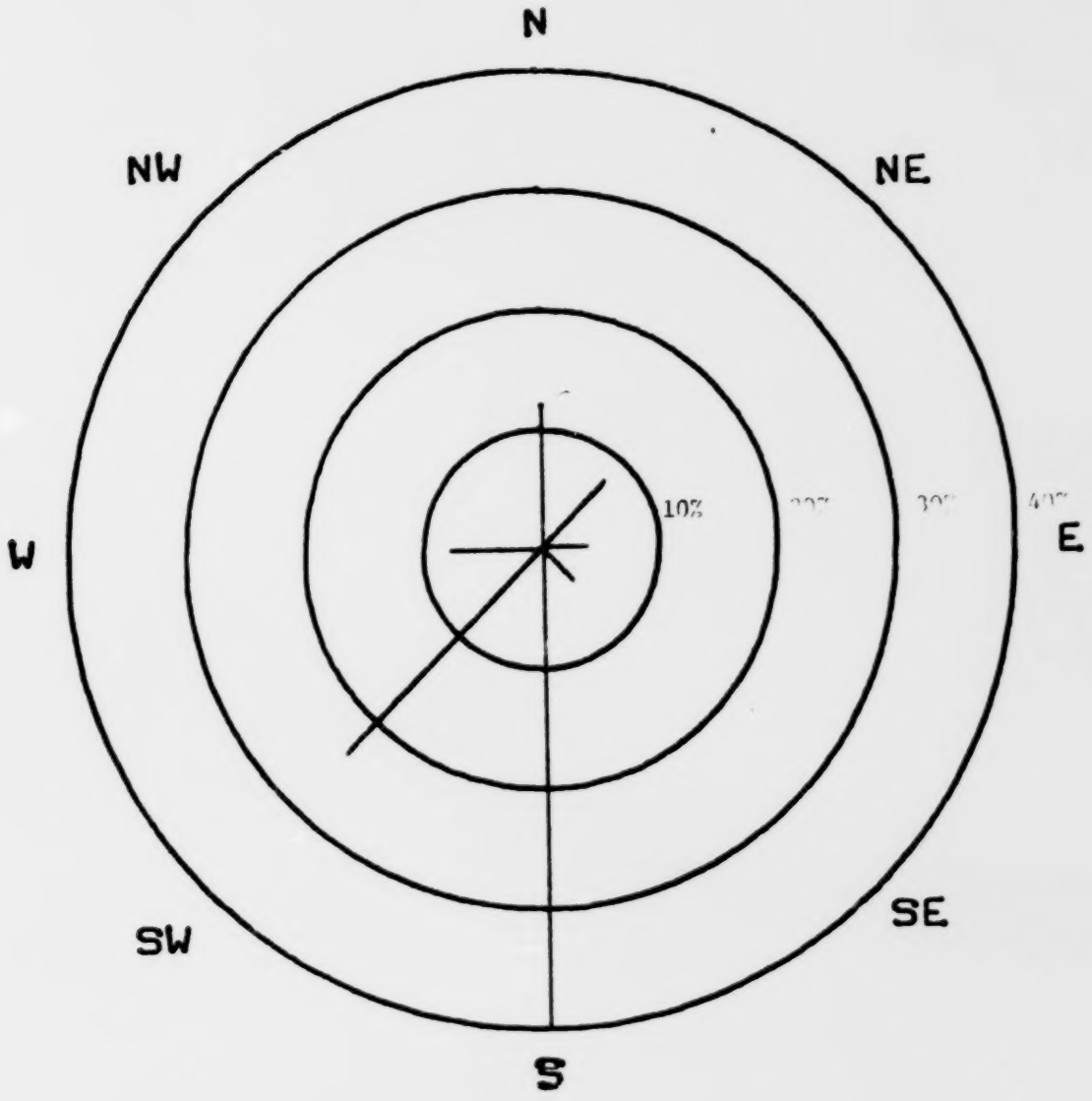
$t_{.95}$ (22) 1.717

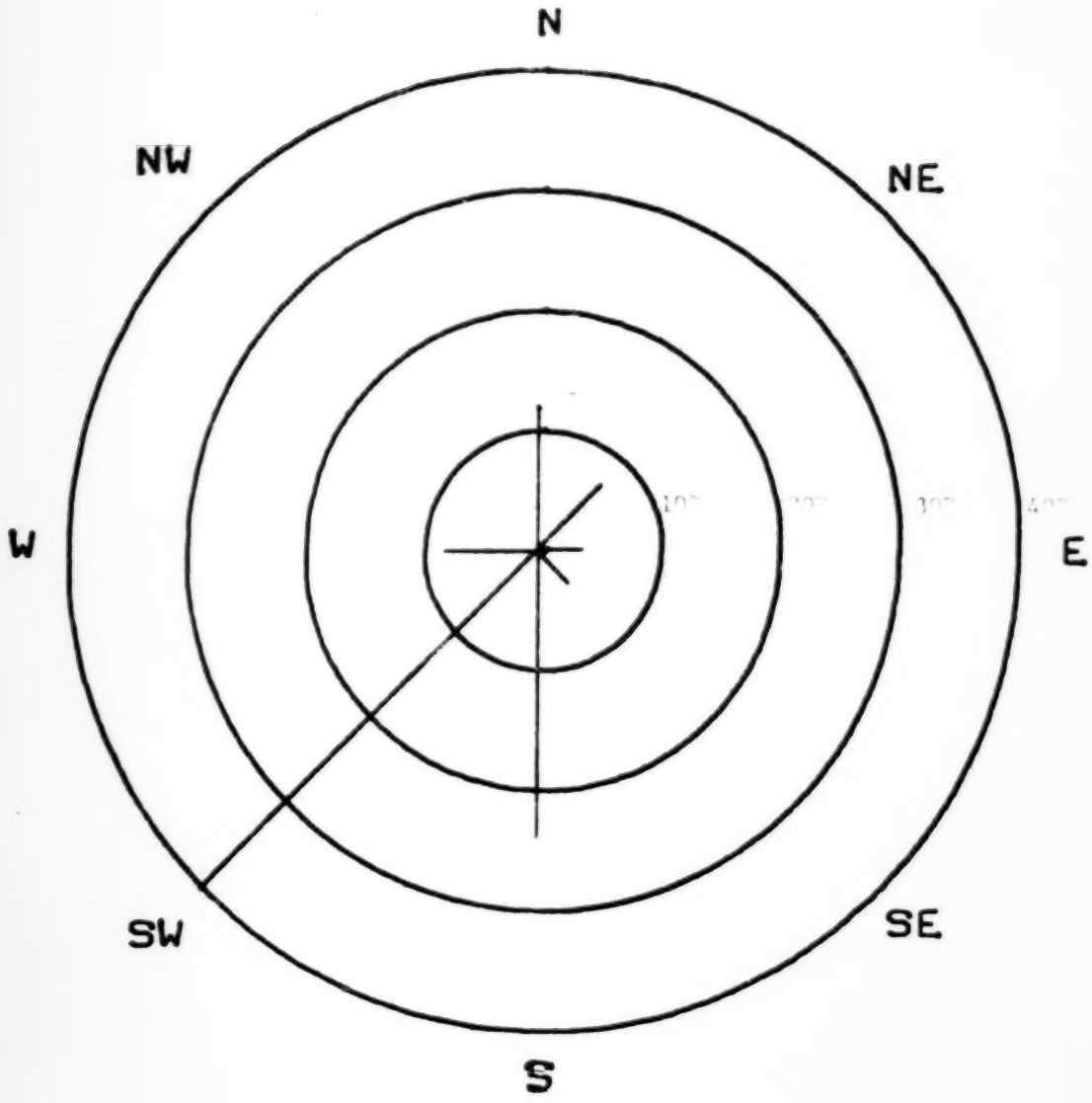
$$U = 1.717 \quad \left(\frac{.1}{\sqrt{23}} \right) = .0358$$

$\left|\bar{X}_d\right| < U$ The sites are not significantly different

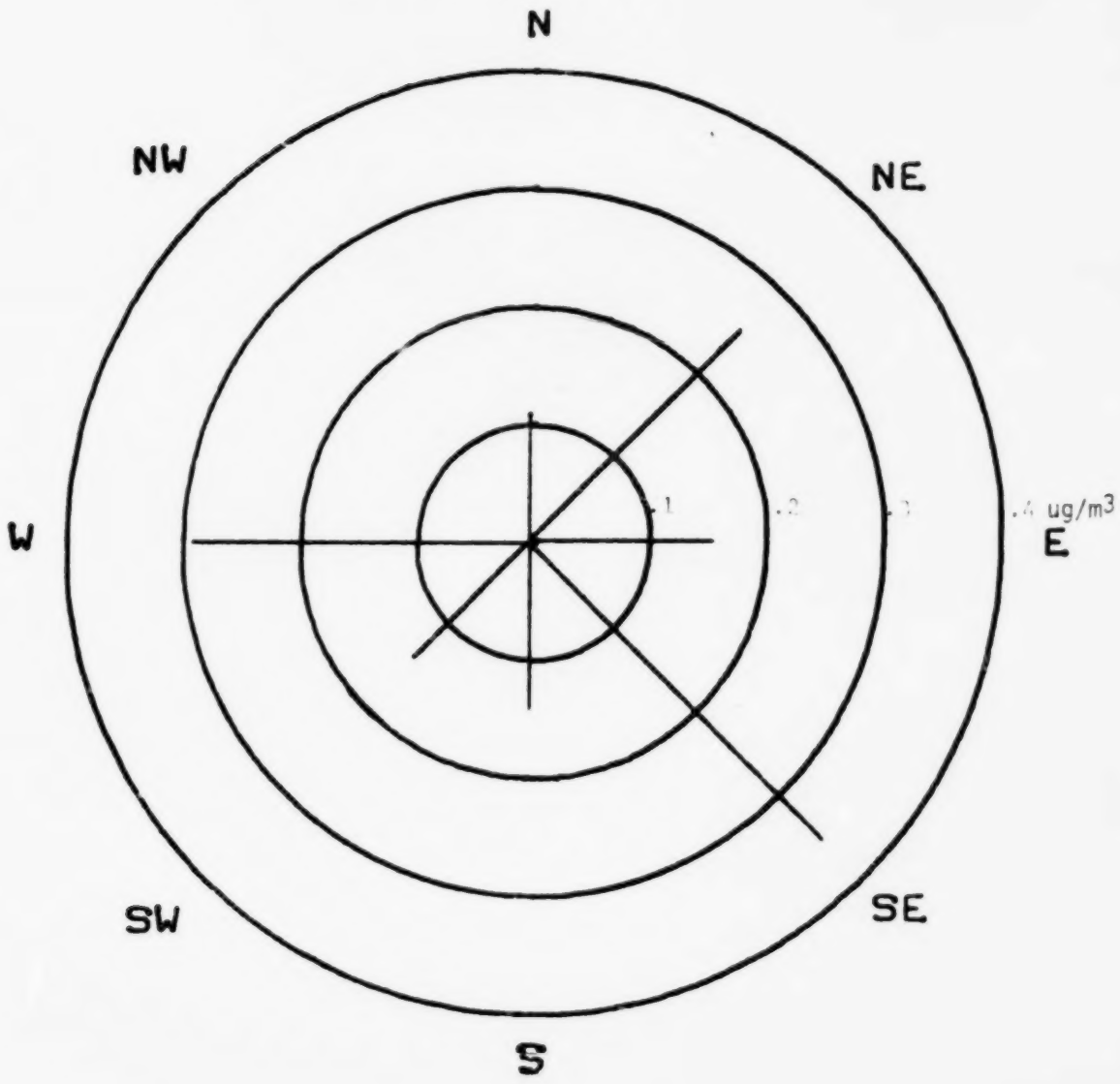
APPENDIX F

WIND DATA AND RELATED PCB CONCENTRATIONS

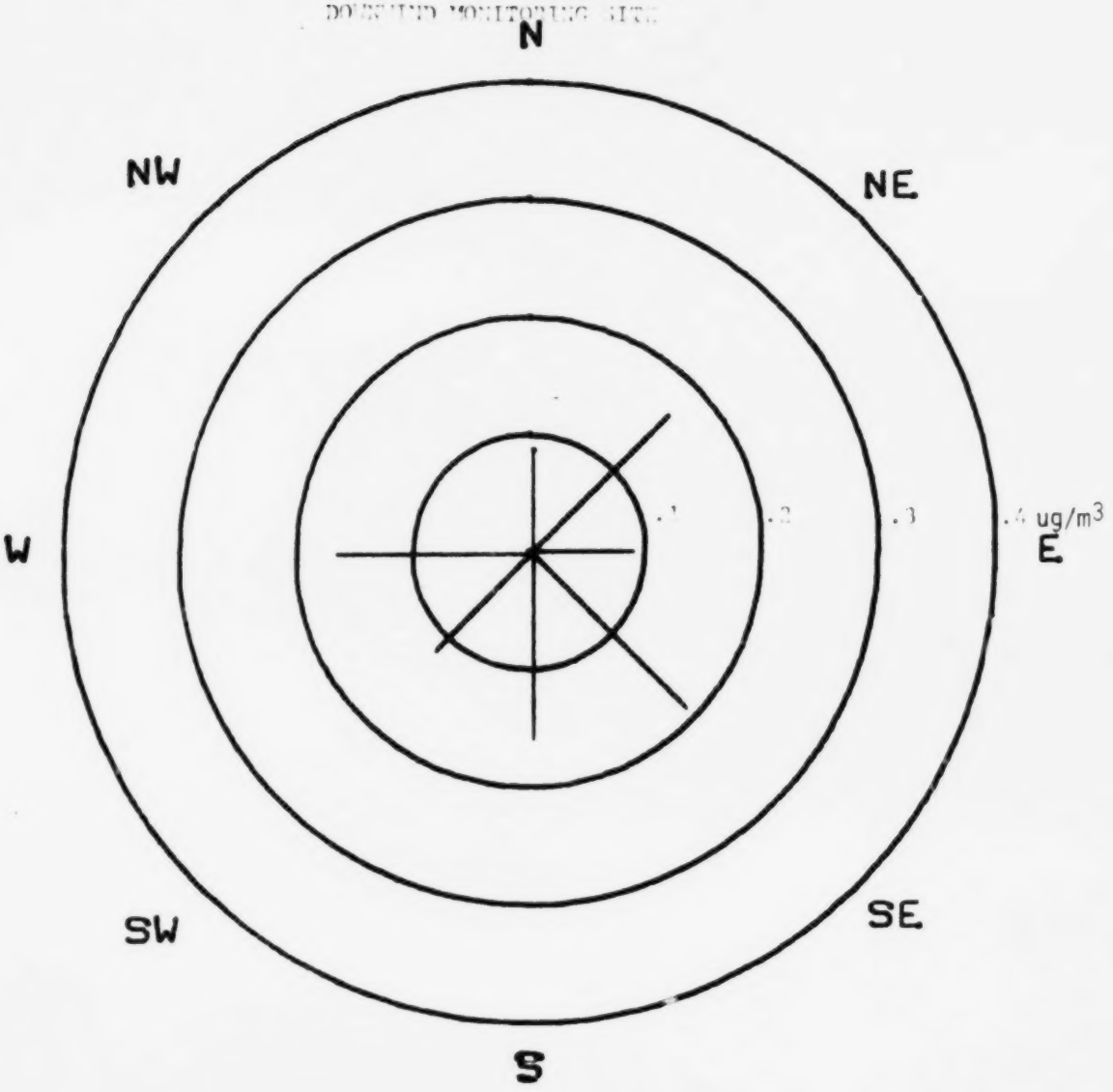

N
NE
E
SE
S
SW
W
NW
10%


N
NW
NE
W
E
SW
SE
S

AVERAGE PCB POLLUTION ROSE
UP WIND TOPOTHORIC SITE



AVERAGE PCB POLLUTION ROSE
DOLESKID MONITORING SITE



AVERAGE PCB POLLUTION ROSE
UPWIND AND DOWNWIND SITES AVERAGE